AMENDMENTS TO THE SPECIFICATION

Please replace the Abstract with the new Abstract below. A clean copy of the new Abstract is submitted herewith on a separate page at the end of this Amendment.

Abstract

~~A measuring apparatus comprising a novel wavefront sensor having a novel aberration means which can be constructed as a diffractive optical element (DOE) and which is suitable for use in adaptive optics. The measuring apparatus can determine the shape of an input radiation wavefront, which is mathematically describable at a predetermined location in an optical system. The apparatus has aberration means, the shape of which is defined by a filter function, detection means with a radiation sensitive surface for detecting the intensity of incident radiation on the surface. The detection means is coupled to an output device that provides a measure of the intensity of the incident radiation. The aberration means is shaped according to a generalised mathematical formula to act on any input wavefront shape to produce first and second output radiation signals that in combination provide data from the output device on the extent to which the wavefront shape is non-planar. The apparatus is able to analyse wavefronts which are scintillated or discontinuous or which has disconnected wavefront segments.~~ A measuring apparatus provides data relating to the shape of an input radiation wavefront, the wavefront shape being describable at a pre-determined location in an optical system. The apparatus includes an aberration device which provides an aberration to the input radiation wavefront, the shape of which is defined by a filter function that is complex valued and has non-mixed symmetry, and a detector having a radiation sensitive surface capable of detecting the intensity of incident radiation on the surface, the detector being coupled to an output device that provides a measure of the intensity of the incident radiation. The aberration device is configured to act on an input wavefront shape to produce first and second output

radiation signals that are detected by the detector and in combination cause the output device to provide data indicating an extent to which the wavefront shape is non-planar.

Please replace the paragraph beginning on page 2, line 32, with the following rewritten paragraph.

Figure 1b shows that ambiguity can arise if the curvature of the wavefront [[11]]8 is so severe that a focus point occurs within the volume sampled by the measurements. The upper part of each figure leads to the same intensity increase.

Please replace the paragraph beginning on page 16, line 16, with the following rewritten paragraph.

Figures 1a and 1b show a series of wavefronts propagating and ~~illustrates~~ illustrate variations in local beam intensity;

Figure 2 illustrates a wavefront and a diffractive optical element which provides the aberration means;

Figure 3 illustrates a phase diversity wavefront sensor according to an embodiment of the present invention;

Figures 4a to 4d show simulation ~~result~~ results with ~~the~~ a non-plane wavefront input and ~~the~~ an even symmetry phase diversity filter;

Figure 5 shows a phase diversity wavefront sensor according to a second embodiment of the present invention;

Figure 6 shows a phase diversity wavefront sensor according to a third embodiment of the present invention;

Figure 7 shows a phase diversity wavefront sensor according to a fourth embodiment of the present invention;

Figure 8 shows a phase diversity wavefront sensor according to a fifth embodiment of the present invention;

Figure 9 shows results with the Zernike polynomial Z_{10}^{0} phase diversity filter used to create aberration means;
Figure 10(a) (i) to (iii) show the wavefront intensity of a wavefront in the pupil phase, the output intensity distribution of a difference image and the associated prior art quadratic diffractive optical element;
Figures [[11]]10(b) (i) and (iii) show ~~an embodiment of the present invention and illustrate~~ the wavefront intensity of a wavefront in the pupil phase, the output intensity distribution of a difference image and the associated pure spherical diffractive optical element according to an embodiment of the present invention; and
Figures [[1]]11(a) to 11(b) show a discontinuous pupil phase wavefront and outputs with a prior art defocus grating and a grating according to the present invention.

Please replace the paragraph beginning on page 17, line 20, with the following rewritten paragraph.

Figure 3 shows the combination of DOE 27 (diffraction grating) with SLM 29 (spatial line modulator) operated using liquid crystals in this example. The wavefront modulators are used to produce an adaptive optical system for driving a null sensor. In figure 3 the CMOS (complementary metal oxide semiconductor) camera 23 used to detect the j+1 and j-1 signals is shown along with the lens [[27]]25 and logic circuit 31 which provides an electrical control system that is used to control the SLM 29 thereby altering the shape of the wavefront in response to errors detected in the j+1 and j-1 signals.

Please replace the paragraph beginning on page 19, line 22, with the following rewritten paragraph.

Figure 5 shows an embodiment 35 of the present invention in which an input/test wavefront 37 is shown at a position remote from a lens/grating 39. A modulator 41 is

also shown connected to the output 51 of the logic circuit 49 which is used to calculate the difference in the intensity signals generated at I_1 and I_2 denoted by reference numerals 43 and 45 respectively. I_0 denoted by reference numeral 47 describes the position of the image of the wavefront 37.

Please replace the paragraph beginning on page 19, line 28, with the following rewritten paragraph.

In this example of the present invention, the input/test wavefront is positioned remotely from the lens/grating 39. It has been found that such an arrangement provides a sufficient degree of spatial resolution of the I_1 and I_2 signals to allow the actual position in the wave front of the non-planar part to be identified. This feature is particularly useful where the present invention is to be used as an adaptive optical device for the correction of input wavefronts. In this example, the measured, spatially separated values of I_1 and I_2 will contain dark and bright areas where the wavefront has deviated from being a planar wavefront. Once the difference between the calculated values of I_1 and I_2 has been calculated, the logic circuit [[40]]49 will create a signal which allows the modulator to adjust the shape of the wavefront to make it planar.

Please replace the paragraph beginning on page 21, line 5, with the following rewritten paragraph.

Figures 9a and 9b show the original signal phase and the retrieved signal phase. Figure 9c shows the difference between these phases, Figure [[9c]]9d shows the ln error value plotted against the number of iterations and Figures 9e and 9f show the I+1 and I-1 images.

Please replace the paragraph beginning on page 22, line 4, with the following rewritten paragraph.

Figures 11a and 11b show wavefront intensity in the pupil phase and output intensity after the wavefront has passed through a defocus ~~gravity~~ grating as shown in figure 10(a)(iii). Figures 11c and 11d show wavefront intensity in the pupil phase and output intensity after the wavefront has passed through a spherical aberration diffraction ~~gravity~~ grating as shown in figure 10(b)(iii). In both figures 11(a) and 11(c), the input wavefronts are identical and have a central obscuration 50 in the centre of the wavefront. The central obscuration shown is of the type found in telescopes.

Please replace the paragraph beginning on page 22, line 12, with the following rewritten paragraph.

It can be seen from figure 11(b) that there are a number of features around the boundary of the central obscuration 52 when the wavefront passes through a defocus ~~gravity~~ grating. These features arise because of the sensitivity of the defocus ~~gravity~~ grating to the missing boundary and do not represent errors in the wavefront, but are created by the optical properties of the defocus ~~gravity~~ grating. In a wavefront sensor, the presence of such features would prevent accurate modification of the wavefront shape and prevent the creation of a plane wavefront.